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Original Research Article

Trends in otolaryngology-head and neck surgery procedural volumes during the COVID-19 pandemic

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ABSTRACT

Background: The COVID-19 pandemic significantly impacted procedural volumes across all surgical specialties. This study aims to assess trends two years after the start of the pandemic and analyze the current surgical volume in Otolaryngology-Head and Neck Surgery.
Methods: The COVID-19 TriNetX database, consisting of 67 health care organizations (HCOs) was utilized to collect de-identified data patients that underwent otolaryngologic surgical procedures from February 1, 2018 to January 31, 2022. The pre-pandemic (2018 to 2019) and post-pandemic (2020 to 2021) periods were analyzed and compared for surgical volumes by season, surgical subspecialty, and procedure type. Student's t-test was utilized to test for statistical significance of trends between seasonal averages pre- and post-pandemic.
Results: A total of 2,005,796 otolaryngology surgical procedures from 45 HCOs were included. When comparing the average monthly post-pandemic (2020 and 2021) volumes to their pre-pandemic (2018 and 2019) seasonal counterparts, there were statistically significant decreases in the averages of all seasons. Post-pandemic seasonal volumes assessed by individual years depicted a significant decline in the total otolaryngology surgical volumes in all seasons, with the steepest reduction from Winter 2019 to Spring 2020.
Conclusions: Specialties that experienced significant reductions in volume without sufficient evidence of rebounding trends include paediatric otolaryngology and otology, while general/rhinology/endoscopy, laryngology, head and neck surgery, and facial plastics and reconstructive surgery are trending towards pre-pandemic baselines.

Keywords: COVID-19, Surgical volumes, Public health

INTRODUCTION

The novel coronavirus disease (COVID-19) outbreak, caused by severe acute respiratory syndrome coronavirus 2 SARS-CoV-2 (SARS-CoV-19) pandemic significantly impacted healthcare organizations worldwide. Heightened precautions led to decreased elective surgical procedural volumes and hospital visits across all specialties, particularly during the initial months and subsequent surges of the pandemic.[1,2] Guidelines and recommendations from numerous governing medical organizations were published to direct practitioners on

providing care during this time.[3] The American College of Surgeons (ACS) released guidelines in March, 2020 stating that practitioners should triage their cases provide patient care to individuals with time-sensitive, urgent, and emergent medical conditions only.[4] With increased data on transmission and infection rates, elective surgical procedures were gradually restarted.

There has been increased concern among returning to pre-pandemic surgical volumes among otolaryngologists due to the most surgical procedures involving the upper aerodigestive tract and a higher chance of COVID-19 transmission. The American Academy of Otolaryngology-Head and Neck Surgery published specific guidelines due to perceived higher risk of exposure to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) among otolaryngologists. American Academy of Otolaryngology-Head and Neck Surgery, 2020; Piccirillo, 2020). The guidelines specify factors to stratify risk and urgency of surgical interventions and specifically caution against conducting aerosol-generating procedures.[5,7] Aggregate ENT procedural volumes, compared to those of other specialties, experienced the steepest declines during the initial phases of the pandemic.8 One year after the pandemic, ENT was the only specialty to maintain decreased surgical volumes compared to pre-pandemic volumes.[8]

The COVID-19 TrinetX (Cambridge, MA) database is a rapidly growing global network of electronic medical record (EMR) data with extensive information on over 90 million patients from 67 healthcare organizations (HCOs).[9] The database provides HIPAA-compliant, de-identified patient information on demographics, medical history, inpatient diagnoses, treatments, laboratory values, and clinical outcomes. Importantly, the COVID-19 TrinetX database provides information on the number of procedures performed. The objectives of this study are to characterize rebounding trends in ENT surgical volumes within two years of the pandemic and to assess trends based on ENT sub-specialty.

METHODS

The data included in this study represents the available data within the TriNetX database COVID-19 research network as of March 15, 2022. Given the publicly available, de-identified nature of the dataset, Institutional Review Board approval was not required.

The Otolaryngology Case Log Coding Guidelines, created by the ACGME Review Committee for Otolaryngology-Head and Neck Surgery, was used to determine the most relevant surgical procedures.[10] The guidelines assist ACGME-accredited otolaryngology programs by setting nationwide benchmarks regarding surgical volume and expertise, ensuring a high standard of surgical training and a degree of uniformity for all otolaryngology residency training programs. The 30 most common otolaryngology procedures and associated Current Procedural Terminology (CPT) from the guidelines were compiled and included for analysis (Table 1).

Table 1: 30 most common otolaryngology procedures and procedural categories.

CPT codes	Procedure names	Number of healthcare organizations (HCO)
General/endoscopy/rhinology		
1007164	Incision and drainage abscess (of pharynx, adenoids, and tonsils)	42
1005716	Removal foreign body, intranasal	42
30901	Control nasal hemorrhage, anterior, simple (limited cautery and/or packing) any method	42
30930	Fracture nasal inferior turbinate(s), therapeutic	33
1005899	Bronchoscopy, rigid or flexible, including fluoroscopic guidance, when performed	45
31500	Intubation, endotracheal, emergency procedure	41
1005884	Incision procedures on the trachea and bronchi (tracheostomy)	37
1007242	Esophagoscopy, flexible, transoral	39
30140	Submucous resection inferior turbinate, partial or complete, any method	41
1005788	Endoscopy procedures on the accessory sinuses (surgical and diagnostic nasal/sinus endoscopy)	42
Pediatric ENT		
1007162	Surgical procedures on the pharynx, adenoids, and tonsils	44
Laryngology		
1005837	Endoscopy procedures on the larynx (indirect, direct, and flexible laryngoscopy)	43
Head and neck surgery		
1009025	Surgical procedures on the thyroid gland	42
1014226	Parathyroidectomy or exploration of parathyroid(s)	36

Continued.

CPT codes	Procedure names	Number of healthcare organizations (HCO)
38724	Cervical lymphadenectomy (modified radical neck dissection)	33
1003996	Excision procedures on the neck (soft tissues) and thorax	41
1007088	Surgical procedures on the palate and uvula	41
1007121	Surgical procedures on the salivary gland and ducts	41
1007019	Surgical procedures on the tongue and floor of mouth	41
1006965	Surgical procedures on the lips	35
1006988	Surgical procedures on the vestibule of mouth	42
Facial plastic and reconstructive surgery		
1031037	Muscle, myocutaneous, or fasciocutaneous flap	36
1003752	Bone graft, any donor area	32
1003380	Adjacent tissue transfer or rearrangement, eyelids, nose, ears and/or lips	38
1005720	Repair procedures on the nose	41
1007101	Repair procedures on the palate and uvula	24
15120	Split-thickness autograft, face, scalp, eyelids, mouth, neck, ears, orbits, genitalia, hands, feet, and/or multiple digits; first 100 sq cm or less, or 1% of body area of infants and children (except 15050)	35
1003428	Full thickness graft, free, including direct closure of donor site, nose, ears, eyelids, and/or lips	34
21235	Graft; ear cartilage, autogenous, to nose or ear (includes obtaining graft)	34
Otology/neurotology		
1010115	Surgical procedures on the auditory system	42

The database was queried for monthly case volume of inpatient and outpatient ENT-related procedures between February 1, 2018 and January 31, 2022. The timeline was chosen to equally represent two years before the pandemic, assuming the pandemic had global significant impact by February 1st, 2020, and two years after the start of the pandemic. Corresponding number of reporting HCOs, which varied for each procedure and each month, were averaged for each procedure, and compiled for analysis. Monthly CPT-specific procedural volumes per HCO were categorized based on 3-month seasons. Seasonal averages (March to May, June to August, September to November, December to February) were analyzed from February 1st, 2018 to January 31st, 2022. Seasonal averages from 2018 and 2019 were combined to offer an accurate assessment of pre-pandemic volumes. Seasonal averages from 2020 and 2021 were similarly combined to explore the lasting impact of the pandemic. Pre- and post-pandemic seasonal averages were compared on a seasonal basis. Data was recorded and analyzed on Microsoft Excel. Student's t-test was utilized to test for statistical significance and a $p<0.05$ was considered significant.

RESULTS

A total of 2,005,796 ENT surgical procedures from 45 HCOs from February 1st, 2018 to January 31st, 2022 were analyzed in this study. Months were grouped by season: Spring (March, April, May), Summer (June, July, August), Fall (September, October, November), and Winter (December, January, February). In our analysis, the pre-pandemic time period was from February 1st, 2018 to February 29th, 2020 and the post-pandemic time period was from March 1st, 2020 to January 31st, 2022.

Trends by season

When comparing the average monthly post-pandemic (2020 and 2021) volumes to their pre-pandemic (2018 and 2019) seasonal counterparts, there were statistically significant decreases in the average monthly ENT surgical volumes in all seasons. When compared to average two-year pre-pandemic volumes, average two-year post-pandemic volumes decreased in the Spring (-27%, $p=0.0297$), Summer (-14%, $p<0.0001$), Fall (-14%, $p=0.001$), and Winter (-26%, $p=0.006$) (Figure 1). When assessing post-pandemic seasonal volumes by individual years, total ENT surgical volumes significantly decreased in all seasons, with the steepest decrease from Winter 2019 to Spring 2020, representing the start of the COVID-19 pandemic (Figure 2). Compared to 2019 seasonal volumes, total ENT surgeries decreased in Spring 2020 (-49%, $p=0.017$), Summer 2020 (-16%, $p=0.044$), Fall 2020 (-25%, $p=0.0017$), Winter 2020 (-25%, $p=0.0017$), Spring 2021 (-13%, $p=0.0174$), Summer 2021 (-14%, $p=0.0036$), and Fall 2021 (-16%, $p=0.0249$). Statistical analysis could not be conducted on Winter 2021 since data was not available for February 2022.

Trends by specialty

Average monthly post-pandemic surgical volumes (2020 and 2021 seasons) were then compared to pre-pandemic volumes (2018 and 2019 seasons) by otolaryngology specialty to assess individual trends (Figure 3, Figure 4,

Table 2). General/endoscopic/rhinology procedures significantly decreased in the Winter, Spring, and Summer of 2020 (-11%, p=0.0358; -37%, p=0.0025; -11%, p=0.0024; respectively). The only significant volume decrease in this sub-specialty in 2021 was in the Winter season (-29%, p=0.0036). Laryngology procedures followed a similar trend, with a significant decrease in Winter, Spring, and Summer of 2020 (-16%, p=0.0099; -56%, p=0.0006; -19%, p=0.0002; respectively) and during the Winter of 2021 (-27%, p=0.0036). Head and Neck surgical volumes significantly decreased in the Winter, Spring, and Summer of 2020 (-11%, p=0.0275; -34%, p=0.0049; -8%, p=0.0135; respectively), and Fall and Winter of 2021 had significantly decreased volumes compared to pre-pandemic volumes (-17%, p=0.0029; and -34%, p=0.0005; respectively). Facial plastics and reconstructive surgery experienced significantly decreased volumes in the Spring and Summer seasons of 2020 (-39%, p=0.002; and -7%, p=0.0093; respectively). In 2021, Winter and fall season demonstrated significant decreases in volume (-34%, p=0.0005; and -17%, p=0.0029; respectively). Contrary to those of other subspecialties, paediatric and otologic procedures experienced significant decreases in all seasons of 2020 and trends were maintained in 2021.

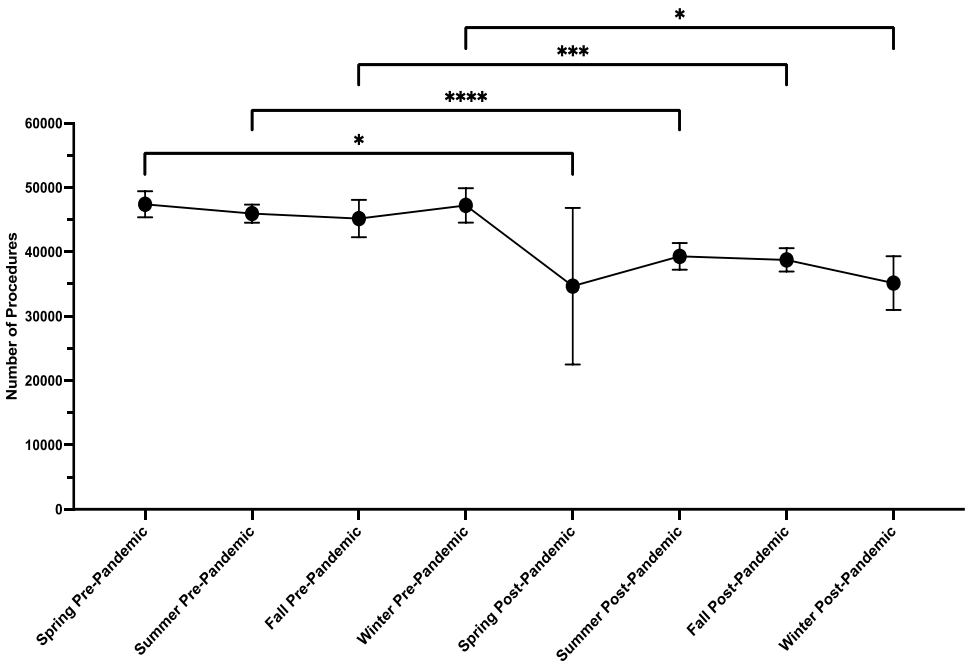

Figure 1: Two-year average monthly pre- and post-pandemic otolaryngology procedural volumes.

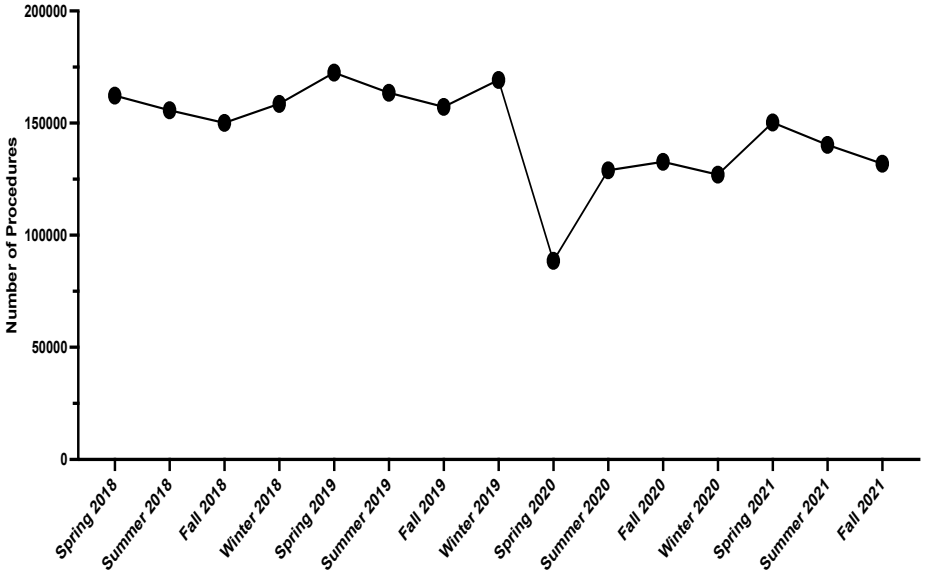

Figure 2: Total monthly otolaryngology procedures two years pre- and post-pandemic.

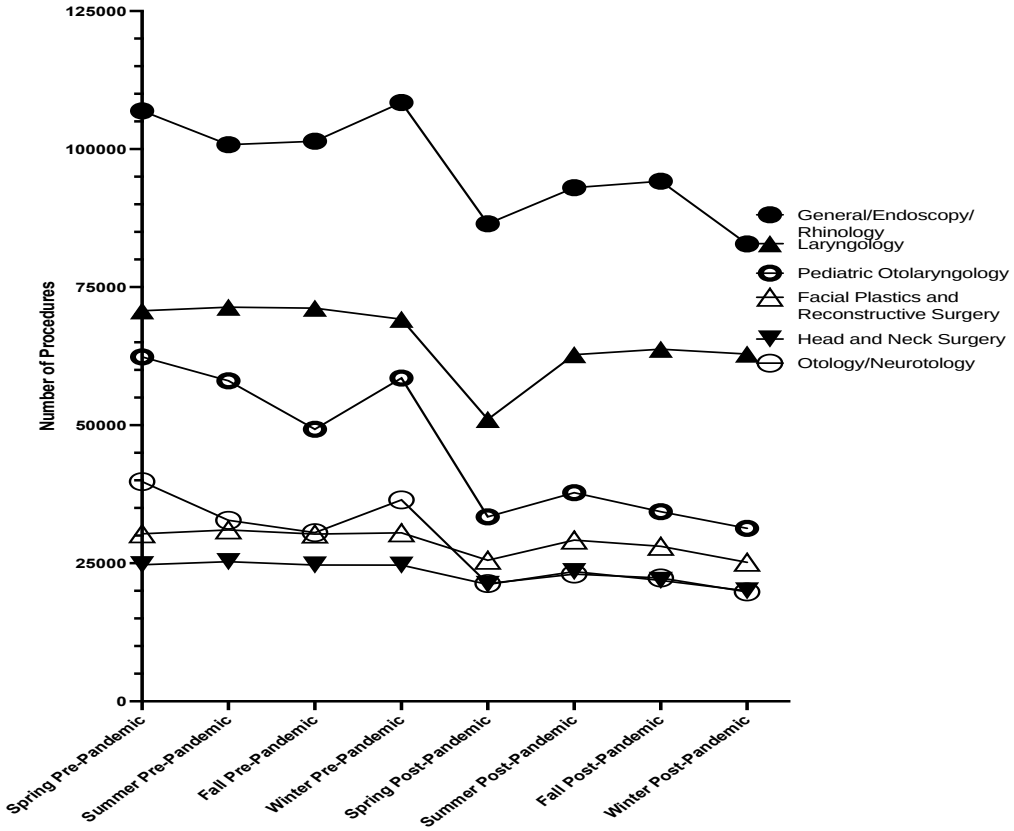

Figure 3: Two-year average otolaryngology procedures by specialty.

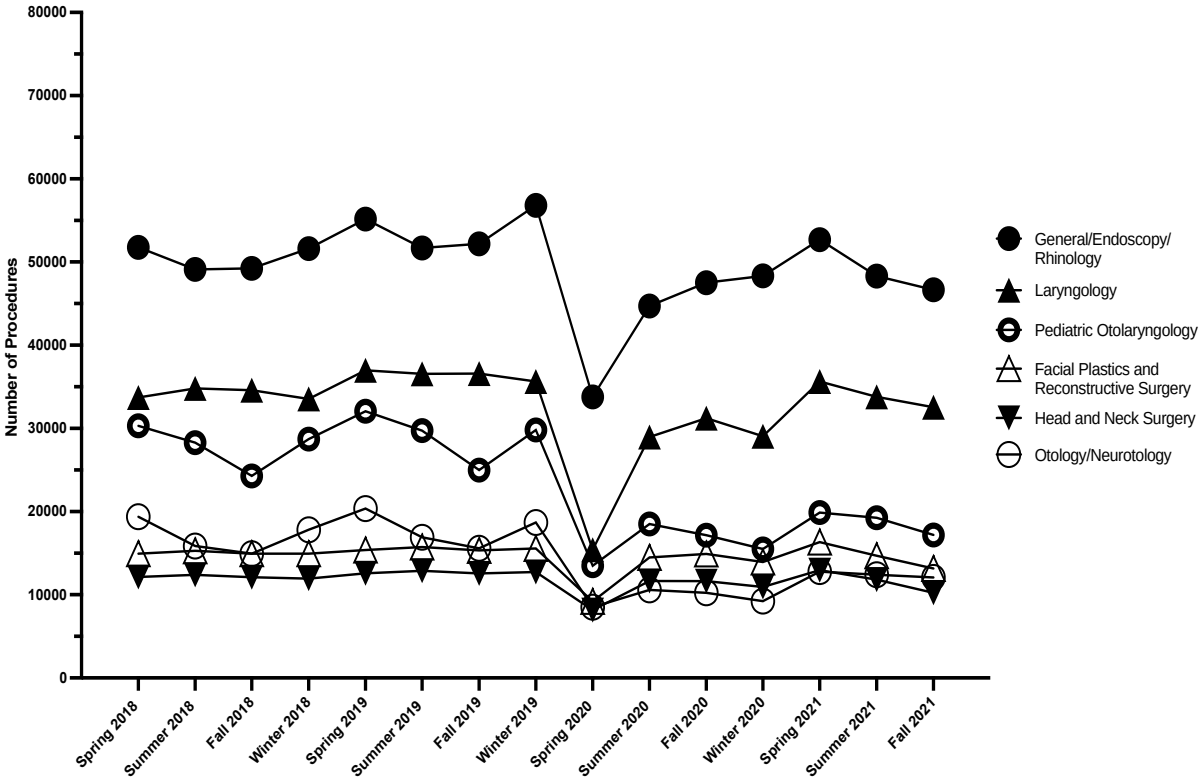

Figure 4: Yearly otolaryngology procedures by sub-specialty.

Table 2: Post-pandemic otolaryngology procedural volume changes compared to pre-pandemic baselines.

Season	Year	General/endoscopy/ rhinology		Laryngology		Pediatric otolaryngology		Head and neck surgery		Facial plastics and reconstructive surgery		Otology	
		% Change	P value	% Change	P value	% Change	P value	% Change	P value	% Change	P value	% Change	P value
Winter	2020	-11	0.0358	-16	0.0099	-47	<0.0001	-11	0.0275	-9	0.0552	-49	0.0001
	2021	-29	0.0036	-27	0.0036	-47	<0.0001	-34	0.0005	-33	0.0006	-42	0.0021
	2020/ 2021	-18	0.0098	-20	0.0014	-47	<0.0001	-20	0.092	-19	0.204	-46	<0.0001
Spring	2020	-37	0.0025	-56	0.0006	-57	0.0006	-34	0.0049	-39	0.002	-57	0.0004
	2021	-1	0.6766	0	0.8571	-36	<0.0001	5	0.2822	8	0.0696	-36	<0.0001
	2020/ 2021	-19	0.0782	-28	0.0829	-46	0.0002	-14	0.2015	-16	0.2177	-46	0.0002
Summer	2020	-11	0.0024	-19	0.0002	-36	<0.0001	-8	0.0135	-7	0.0093	-35	<0.0001
	2021	-4	0.1419	-5	0.0906	-34	<0.0001	-7	0.1474	-5	0.1625	-25	<0.0001
	2020/ 2021	-8	0.0101	-12	0.074	-35	<0.0001	-7	0.0269	-6	0.0309	-30	<0.0001
Fall	2020	-6	0.1978	-12	0.0526	-30	0.0002	-6	0.2426	-2	0.7221	-33	0.0002
	2021	-8	0.1003	-9	0.1	-30	<0.0001	-17	0.0029	-13	0.0034	-21	0.0012
	2020/ 2021	-7	0.0492	-10	0.0209	-30	<0.0001	-11	0.0187	-7	0.0905	-27	<0.0001

Table 3: Seasonal mean otolaryngology procedural volumes per HCO for Spring pre-pandemic seasons (March 2018, April 2018, May 2018, March 2019, April 2019, May 2019) and Spring post-pandemic seasons (March 2020, April 2020, May 2020, Mar 2021, April 2021, May 2021).

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
General/endoscopy/rhinology				
Incision and drainage abscess	3.87 (0.48)	3.08 (0.90)	-20.23	0.16
Removal foreign body, intranasal	4.73 (0.24)	4.82 (0.42)	1.93	0.67
Control nasal hemorrhage, anterior, simple (limited cautery and/or packing) any method	21.60 (1.27)	18.88 (4.61)	-12.62	0.18
Fracture nasal inferior turbinate(s), therapeutic	5.78 (0.6)	4.22 (2.21)	-27.07	0.14
Bronchoscopy, rigid or flexible, including fluoroscopic guidance, when performed	88.93 (2.21)	72.09 (15.94)	-18.93	0.03
Intubation, endotracheal, emergency procedure	65.73 (3.39)	73.03 (8.69)	11.11	0.17
Incision procedures on the trachea and bronchi	13.12 (0.69)	13.09 (1.23)	-0.24	0.93
Esophagoscopy, flexible, transoral	10.82 (1.03)	8.19 (2.08)	-24.33	0.05

Continued.

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
Submucous resection inferior turbinate, partial or complete, any method	18.38 (1.15)	14.13 (7.75)	-23.11	0.19
Endoscopy procedures on the accessory sinuses	190.51 (10.74)	131.61 (71.53)	-30.92	0.08
Pediatric ENT				
Surgical procedures on the pharynx, adenoids, and tonsils	85.58 (4.46)	45.75 (16.64)	-46.54	<0.001
Laryngology				
Endoscopy procedures on the larynx	274.07 (16.30)	197.93 (95.44)	-27.78	0.07
Head and neck surgery				
Surgical procedures on the thyroid gland	23.67 (1.77)	18.37 (6.03)	-22.38	0.08
Parathyroidectomy or exploration of parathyroid(s)	12.33 (0.99)	9.84 (4.25)	-20.20	0.19
Cervical lymphadenectomy (modified radical neck dissection)	7.19 (0.61)	8.08 (0.72)	12.36	0.11
Excision procedures on the neck (soft tissues) and thorax	10.00 (0.87)	8.25 (3.11)	-17.45	0.16
Surgical procedures on the palate and uvula	6.72 (0.53)	4.86 (1.78)	-27.75	0.06
Surgical procedures on the salivary gland and ducts	10.83 (0.56)	8.80 (2.82)	-18.77	0.11
Surgical procedures on the tongue and floor of mouth	16.18 (1.22)	15.13 (4.07)	-6.48	0.56
Surgical procedures on the lips	6.96 (0.69)	5.81 (1.36)	-16.50	0.04
Surgical procedures on the vestibule of mouth	9.73 (0.46)	9.76 (3.05)	0.33	0.98
Facial plastic and rconstructive surgery				
Muscle, myocutaneous, or fasciocutaneous flap	11.56 (0.68)	10.78 (2.34)	-6.77	0.40
Bone graft, any donor area	5.11 (0.49)	4.15 (1.39)	-18.84	0.16
Adjacent tissue transfer or rearrangement, eyelids, nose, ears and/or lips	17.39 (0.86)	13.86 (4.48)	-20.31	0.08
Repair procedures on the nose	28.26 (1.49)	22.32 (12.22)	-21.03	0.25
Repair procedures on the palate and uvula	5.29 (0.87)	3.66 (1.62)	-30.84	0.06
Split-thickness autograft, face, scalp, eyelids, mouth, neck, ears, orbits, genitalia, hands, feet, and/or multiple digits; first 100 sq cm or less, or 1% of body area of infants and children (except 15050)	6.85 (0.25)	5.91 (1.03)	-13.70	0.08
Full thickness graft, free, including direct closure of donor site, nose, ears, eyelids, and/or lips	8.32 (0.21)	5.98 (2.21)	-28.11	0.05
Graft; ear cartilage, autogenous, to nose or ear (includes obtaining graft)	7.26 (0.70)	5.92 (3.17)	-18.50	0.37
Otology/neurotology				
Surgical procedures on the auditory system	157.81 (5.24)	84.58 (30.38)	-46.41	<0.001

Table 4: Seasonal mean otolaryngology procedural volumes per HCO for Summer pre-pandemic seasons (June 2018, July 2018, August 2018, June 2019, July 2019, Aug 2019) and Summer post-pandemic seasons (June 2020, July 2020, August 2020, June 2021, July 2021, August 2021).

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
General/endoscopy/rhinology				
Incision and drainage abscess	3.55 (0.46)	3.00 (0.24)	-15.44	0.03
Removal foreign body, intranasal	4.77 (0.37)	4.50 (0.53)	-5.74	0.44
Control nasal hemorrhage, anterior, simple (limited cautery and/or packing) any method	18.12 (0.54)	16.36 (1.36)	-9.72	0.04
Fracture nasal inferior turbinate(s), therapeutic	5.59 (0.60)	4.55 (2.19)	-18.70	0.38
Bronchoscopy, rigid or flexible, including fluoroscopic guidance, when performed	87.73 (4.02)	76.43 (3.74)	-12.87	0.01
Intubation, endotracheal, emergency procedure	62.18 (3.38)	68.99 (6.51)	10.96	0.11
Incision procedures on the trachea and bronchi	12.88 (1.11)	13.51 (0.56)	4.90	0.13
Esophagoscopy, flexible, transoral	10.76 (0.62)	9.31 (1.05)	-13.46	0.03
Submucous resection inferior turbinate, partial or complete, any method	18.08 (0.74)	17.00 (1.29)	-5.96	0.08
Endoscopy procedures on the accessory sinuses	175.46 (6.46)	155.29 (18.51)	-11.49	0.03
Pediatric ENT				
Surgical procedures on the pharynx, adenoids, and tonsils	95.67 (3.98)	55.84 (6.49)	-41.64	<0.001
Laryngology				
Endoscopy procedures on the larynx	276.65 (1.07)	243.26 (21.81)	-12.07	<0.001
Head and neck surgery				
Surgical procedures on the thyroid gland	24.05 (0.99)	21.23 (1.50)	-11.72	0.02
Parathyroidectomy or exploration of parathyroid(s)	12.16 (0.80)	12.02 (1.46)	-1.18	0.85
Cervical lymphadenectomy (modified radical neck dissection)	7.60 (0.86)	7.35 (0.40)	-3.26	0.59
Excision procedures on the neck (soft tissues) and thorax	10.54 (1.12)	9.22 (0.38)	-12.61	0.04
Surgical procedures on the palate and uvula	6.93 (0.27)	5.87 (0.39)	-15.30	<0.001
Surgical procedures on the salivary gland and ducts	10.96 (0.33)	10.18 (0.75)	-7.09	0.07
Surgical procedures on the tongue and floor of mouth	16.73 (0.72)	16.03 (1.62)	-4.20	0.18
Surgical procedures on the lips	7.05 (0.65)	6.81 (0.82)	-3.31	0.61
Surgical procedures on the vestibule of mouth	9.91 (0.63)	9.85 (0.87)	-0.64	0.89
Facial plastic and rconstructive surgery				
Muscle, myocutaneous, or fasciocutaneous flap	12.00 (0.67)	11.47 (0.93)	-4.36	0.44
Bone graft, any donor area	5.33 (0.33)	4.70 (0.43)	-11.91	0.03
Adjacent tissue transfer or rearrangement, eyelids, nose, ears and/or lips	17.06 (0.73)	15.82 (0.63)	-7.25	0.01
Repair procedures on the nose	29.47 (1.47)	27.45 (2.11)	-6.84	0.07
Repair procedures on the palate and uvula	5.90 (0.47)	4.69 (0.40)	-20.47	<0.001
Split-thickness autograft, face, scalp, eyelids, mouth, neck, ears, orbits, genitalia, hands,	6.87 (0.70)	6.75 (0.55)	-1.73	0.81

Continued.

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
feet, and/or multiple digits; first 100 sq cm or less, or 1% of body area of infants and children (except 15050)				
Full thickness graft, free, including direct closure of donor site, nose, ears, eyelids, and/or lips	8.26 (0.64)	7.83 (0.60)	-5.22	0.21
Graft; ear cartilage, autogenous, to nose or ear (includes obtaining graft)	7.46 (0.41)	6.80 (0.70)	-8.81	0.16
Otology/neurotology				
Surgical procedures on the auditory system	130.07 (5.70)	91.36 (8.95)	-29.76	<0.001

Table 5: Seasonal mean otolaryngology procedural volumes per HCO for fall pre-pandemic seasons (September 2018, October 2018, November 2018, September 2019, October 2019, November 2019) and fall post-pandemic seasons (September 2020, October 2020, November 2020, September 2021, October 2021, November 2021).

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
General/endoscopy/rhinology				
Incision and drainage abscess	3.76 (0.71)	3.44 (0.24)	-8.55	0.38
Removal foreign body, intranasal	4.61 (0.59)	4.26 (1.15)	-7.49	0.50
Control nasal hemorrhage, anterior, simple (limited cautery and/or packing) any method	20.37 (3.06)	17.00 (1.72)	-16.56	0.04
Fracture nasal inferior turbinate(s), therapeutic	4.82 (0.48)	4.96 (0.72)	2.94	0.64
Bronchoscopy, rigid or flexible, including fluoroscopic guidance, when performed	85.93 (6.83)	73.37 (6.89)	-14.62	0.01
Intubation, endotracheal, emergency procedure	63.39 (3.05)	69.11 (6.50)	9.03	0.12
Incision procedures on the trachea and bronchi	12.38 (0.56)	13.54 (1.05)	9.39	0.08
Esophagoscopy, flexible, transoral	10.08 (0.67)	8.60 (1.41)	-14.63	0.05
Submucous resection inferior turbinate, partial or complete, any method	16.86 (1.50)	15.56 (1.48)	-7.71	0.14
Endoscopy procedures on the accessory sinuses	179.27 (14.04)	164.01 (10.44)	-8.51	0.02
Pediatric ENT				
Surgical procedures on the pharynx, adenoids, and tonsils	70.93 (4.90)	45.53 (8.10)	-35.82	<0.001
Laryngology				
Endoscopy procedures on the larynx	275.90 (19.88)	247.19 (16.28)	-10.41	<0.001
Head and neck surgery				
Surgical procedures on the thyroid gland	23.13 (1.51)	19.54 (2.41)	-15.53	0.04
Parathyroidectomy or exploration of parathyroid(s)	11.95 (0.72)	10.96 (1.08)	-8.33	0.01
Cervical lymphadenectomy (modified radical neck dissection)	7.62 (0.71)	7.26 (0.65)	-4.78	0.39
Excision procedures on the neck (soft tissues) and thorax	10.41 (0.59)	9.16 (0.74)	-11.99	0.01

Continued.

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
Surgical procedures on the palate and uvula	6.40 (0.68)	5.15 (0.56)	-19.56	0.01
Surgical procedures on the salivary gland and ducts	11.03 (0.91)	9.84 (0.72)	-10.83	0.02
Surgical procedures on the tongue and floor of mouth	16.14 (1.18)	15.21 (1.53)	-5.79	0.25
Surgical procedures on the lips	6.96 (0.74)	5.85 (0.54)	-16.01	0.01
Surgical procedures on the vestibule of mouth	9.83 (0.75)	8.94 (1.02)	-9.05	0.08
Facial plastic and rconstructive surgery				
Muscle, myocutaneous, or fasciocutaneous flap	11.92 (0.20)	11.17 (1.92)	-6.33	0.41
Bone graft, any donor area	5.29 (0.58)	5.36 (0.31)	1.28	0.83
Adjacent tissue transfer or rearrangement, eyelids, nose, ears and/or lips	17.98 (1.65)	16.23 (1.52)	-9.76	0.09
Repair procedures on the nose	26.61 (2.80)	25.27 (2.31)	-5.03	0.34
Repair procedures on the palate and uvula	5.06 (0.86)	3.92 (0.63)	-22.39	0.04
Split-thickness autograft, face, scalp, eyelids, mouth, neck, ears, orbits, genitalia, hands, feet, and/or multiple digits; first 100 sq cm or less, or 1% of body area of infants and children (except 15050)	6.67 (0.34)	6.41 (0.95)	-3.86	0.63
Full thickness graft, free, including direct closure of donor site, nose, ears, eyelids, and/or lips	8.68 (0.29)	8.24 (1.06)	-5.08	0.30
Graft; ear cartilage, autogenous, to nose or ear (includes obtaining graft)	7.49 (0.35)	7.21 (0.59)	-3.73	0.31
Otology/neurotology				
Surgical procedures on the auditory system	121.17 (8.54)	88.60 (9.48)	-26.88	<0.001

Table 6: Seasonal mean otolaryngology procedural volumes per HCO for Winter pre-pandemic seasons (December 2018, January 2019, February 2019, December 2019, January 2019) and Winter post-pandemic seasons (December 2020, January 2021, February 2021, December 2021, January 2022).

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
General/endoscopy/rhinology				
Incision and drainage abscess	4.51 (0.59)	3.27 (0.51)	-27.53	0.04
Removal foreign body, intranasal	4.80 (0.55)	4.11 (1.07)	-14.29	0.37
Control nasal hemorrhage, anterior, simple (limited cautery and/or packing) any method	23.98 (1.19)	18.07 (3.31)	-24.64	0.03
Fracture nasal inferior turbinate(s), therapeutic	5.46 (0.54)	4.92 (1.33)	-9.99	0.24
Bronchoscopy, rigid or flexible, including fluoroscopic guidance, when performed	85.76 (6.65)	65.80 (10.93)	-23.27	0.06
Intubation, endotracheal, emergency procedure	69.88 (5.54)	79.68 (14.87)	-0.28	0.98
Incision procedures on the trachea and bronchi	13.54 (0.82)	13.06 (2.48)	-3.51	0.74
Esophagoscopy, flexible, transoral	9.81 (0.50)	7.02 (1.59)	-28.49	0.02
Submucous resection inferior turbinate, partial or complete, any method	18.41 (2.07)	14.86 (4.42)	-19.29	0.14

Continued.

CPT Codes	Pre-pandemic seasonal mean (SD)	Pandemic seasonal mean (SD)	Percentage change (%)	P value
Endoscopy procedures on the accessory sinuses	189.37 (16.85)	152.52 (13.74)	-19.46	0.05
Pediatric ENT				
Surgical procedures on the pharynx, adenoids, and tonsils	83.60 (2.43)	43.26 (7.98)	-48.25	<0.001
Laryngology				
Endoscopy procedures on the larynx	265.94 (20.47)	213.25 (21.10)	-19.82	0.03
Head and neck surgery				
Surgical procedures on the thyroid gland	23.17 (2.00)	17.98 (2.93)	-22.42	0.06
Parathyroidectomy or exploration of parathyroid(s)	11.81 (1.07)	9.66 (1.78)	-18.20	0.16
Cervical lymphadenectomy (modified radical neck dissection)	7.77 (1.34)	6.92 (1.22)	-10.92	0.49
Excision procedures on the neck (soft tissues) and thorax	10.01 (0.61)	7.74 (2.03)	-22.71	0.09
Surgical procedures on the palate and uvula	6.25 (0.91)	4.99 (0.97)	-20.28	0.05
Surgical procedures on the salivary gland and ducts	10.59 (0.77)	7.91 (1.61)	-25.25	0.06
Surgical procedures on the tongue and floor of mouth	10.25 (0.79)	13.74 (2.43)	-15.43	0.13
Surgical procedures on the lips	6.82 (0.56)	4.98 (0.72)	-26.99	<0.001
Surgical procedures on the vestibule of mouth	10.35 (1.09)	8.71 (1.65)	-15.82	0.22
Facial plastic and rconstructive surgery				
Muscle, myocutaneous, or fasciocutaneous flap	10.88 (1.21)	9.76 (1.68)	-10.27	0.39
Bone graft, any donor area	5.37(0.66)	4.96 (1.22)	-7.57	0.63
Adjacent tissue transfer or rearrangement, eyelids, nose, ears and/or lips	17.64 (1.65)	13.78 (2.47)	-21.87	0.07
Repair procedures on the nose	29.69 (3.32)	23.15 (6.71)	-22.03	0.07
Repair procedures on the palate and uvula	4.68 (0.98)	3.91 (0.66)	-16.40	0.11
Split-thickness autograft, face, scalp, eyelids, mouth, neck, ears, orbits, genitalia, hands, feet, and/or multiple digits; first 100 sq cm or less, or 1% of body area of infants and children (except 15050)	6.63 (0.46)	5.45 (1.33)	-17.83	0.20
Full thickness graft, free, including direct closure of donor site, nose, ears, eyelids, and/or lips	8.06 (0.77)	7.14 (1.36)	-11.39	0.27
Graft; ear cartilage, autogenous, to nose or ear (includes obtaining graft)	7.46 (0.28)	6.06 (1.43)	-18.75	0.12
Otology/neurotology				
Surgical procedures on the auditory system	141.54 (11.24)	77.72 (12.82)	-45.09	<0.001

Table 7: Comparison of pre-pandemic (cohort 1) and post-pandemic (cohort 2) patient demographics and comorbidities.

Variable		Cohort 1 (n=880,022)	Cohort 2 (n=764,242)	P value
		N (%)	N (%)	
Age (years) (SD)		46.8 (27.3)	48 (26.4)	<0.0001
Gender (%)	Male	436,406 (50)	378,850 (50)	0.7702
	Female	442,536 (50)	385,240 (50)	0.8785
	Unknown	80 (0)	152 (0)	<0.0001
Ethnicity (%)	Hispanic or Latino	92,814 (10.5)	76,599 (10)	<0.0001
	Not Hispanic or Latino	605,997 (68)	543,945 (71)	<0.0001
	Unknown Ethnicity	181,211 (21)	143,698 (19)	<0.0001
Race (%)	White	601,263 (68)	513,636 (67)	<0.0001
	Black	118,676 (13.5)	100,822 (13.2)	<0.0001
	Asian	20,509 (2.3)	18,575 (2.4)	<0.0001
	Unknown	135,532 (15)	137,582 (17)	<0.0001
Persons with potential health hazards related to socioeconomic and psychosocial circumstances (%)		65,568 (7.5)	56,551 (7.4)	0.1258
Essential hypertension (%)		326,632 (37)	288,029 (38)	<0.0001
Chronic obstructive pulmonary disease (%)		90,392 (10.3)	73,971 (9.7)	<0.0001
Type 2 diabetes mellitus (%)		146,789 (16.7)	129,692 (16.9)	<0.0001
Obesity (%)		140,213 (15.9)	121,220 (15.9)	0.2116
Tobacco use (%)		66,343 (7.5)	59,402 (7.8)	<0.0001
Alcohol related disorders (%)		41,188 (4.7)	35,421 (4.6)	0.1669
Long-term steroid use (%)		61,661 (7)	50,804 (6.6)	<0.0001
Personal history of malignant neoplasm (%)		118,987 (14)	100,467 (13)	<0.0001

Trends by procedure type

The post-pandemic Spring seasons in this study depicted a decline in 26 of 30 procedures, with 5 showing statistically significant decreases (Table 3). The post-pandemic Summer seasons involved a decrease in 28 of 30 procedures, 12 of which were statistically significant (Table 4). The post-pandemic fall seasons involved a decrease in 26 of 30 procedures, half of which exhibited significant decreases (Table 5). Lastly, the post-pandemic Winter seasons revealed decreases in all 30 of the procedures analyzed, with 9 demonstrating significantly decreased volumes (Table 6).

Some procedures experienced significantly decreased volumes in all post-pandemic seasons, including 'Surgical Procedures of the Auditory System', 'Surgical Procedures on the Pharynx, Adenoids, and Tonsils', 'Esophagoscopy, flexible, transoral', and 'Surgical Procedures on the Lips'. Two procedures that had significant decreases in 3 of 4 seasons were 'Bronchoscopy, rigid or flexible' and 'Endoscopy Procedures on the Larynx'. The only procedures to exhibit increased volumes compared to pre-pandemic baselines were 'Intubation, endotracheal, emergency procedure' and I'ncision Procedures on the Trachea and Bronchi'.

Demographics and comorbidities

The differences in patient demographics and comorbidities between pre-pandemic and post-pandemic cohorts was also examined (Table 7). There were 880,022 individuals who underwent an ENT procedure in the pre-pandemic period and 764,242 individuals who underwent an ENT procedure in the post-pandemic period. The 'post-pandemic period' group was slightly older than the 'pre-pandemic period' group (48 vs 46.8 years, $p<0.0001$) but there was no gender difference. The Post-pandemic cohort included a higher prevalence of significant comorbidities, including essential hypertension (38% vs 37%, $p<0.0001$), type 2 diabetes mellitus (16.9% vs 16.7%, $p<0.0001$), and tobacco usage (7.8% vs 7.5%, $p<0.0001$). The same cohort had a lower prevalence of Chronic Obstructive Pulmonary Disease (9.7% vs 10.3%, $p<0.0001$), long-term steroid usage (6.6% vs 7%, $p<0.0001$), and history of malignant neoplasm (13% vs 14%, $p<0.0001$). Rates of obesity were similar between both groups.

DISCUSSION

Using the Trinet X platform, we found that the COVID-19 pandemic significantly decreased the number of Otolaryngology procedures performed. Spring of 2020, which marked the early stage of the pandemic, exhibited the steepest reduction in otolaryngology volumes, decreasing by nearly half compared to the preceding season. The decline in overall volumes mirrored those of other specialties. However, while volumes of other specialties returned to or near baseline, otolaryngology volumes did not. Two years after the onset of the pandemic there has been a gradually increasing trend in volumes in the number of procedures performed, but case volumes are still lower than before the pandemic.

Mehbrabian et al reviewed the TriNetX database to measure pre- and post-pandemic trends in plastic and reconstructive surgical volumes. Decreasing trends were observed for most procedures, but volumes rebounded within 1 year of the pandemic.[2] When analyzing surgical volume trends during the first post-pandemic year, Mattingly et al observed that Otolaryngology and musculoskeletal procedures experienced the steepest decrease in the first year of the pandemic compared to other procedural volumes.[8] They further observed that by the time of the COVID-19 surges in the Fall and Winter of 2020, surgical volumes across all specialties returned to pre-pandemic baselines except for otolaryngology.[8] Our study found that otolaryngology volumes trended upwards in 2021, suggesting potential return to pre-pandemic baselines. The trends were observed when ENT volumes were analyzed based on surgical subspecialty, including General/Endoscopy/Rhinology, Laryngology, Head and Neck Surgery, and Facial Plastics and Reconstructive Surgery.

While otolaryngology emergencies are common, many frequently performed procedures are elective.[11–13] Guidelines advising against performing elective surgeries significantly impacted surgical volumes, perhaps more so than other fields. In addition, some otolaryngologists may have been more cautious in performing surgical interventions due to their direct involvement with the airway. Aerosol-generating procedures were likely minimized or avoided due to increased risk of contracting SARS CoV-2 given its respiratory droplet-mediated transmission.[14] Cheng et al found that Otolaryngologists had higher rates of COVID-19 infection than physicians in other specialties.[15]

Pediatric otolaryngology and Otology were the only subspecialties that did not exhibit rebounding volumes. Given children's lower risk of developing severe COVID-19 compared to adults, rebounding volumes would be expected, but were not observed.[16] The most common pediatric otolaryngology procedures include adenoidectomies, tonsillectomies, and myringotomies with tympanostomies.[17,18] Since these procedures are largely elective, parents may have been less likely to seek care and surgical intervention. Decreasing pediatric otolaryngology procedures may have also been impacted by social changes induced by the pandemic, including remote learning.[19] Limited interaction with other children in school or daycare may have reduced transmission of upper respiratory infections, thereby decreasing incidence of recurrent tonsillitis, pharyngitis, and acute otitis media. Otology procedures similarly did not return to pre-pandemic baselines. Patients may have been hesitant to seek medical care for common otology procedures, such as cerumen removal, opting for over-the-counter

treatments instead. The trend in Otology procedures may have been impacted by an overlap with pediatric procedures, as tympanostomies with myringotomies were categorized as Otology procedures due to database query limitations.

Only two otolaryngology procedures increased during the post-pandemic period: emergency endotracheal intubation and incision procedures of the trachea. This is unsurprising due to the increased risk of intubation among patients with COVID-19.[20,21] Interestingly, the pre-pandemic cohort had a greater prevalence of COPD, which can contribute to severity of illness presentation and deferral in care to avoid risk of intubation. The pre-pandemic and post-pandemic cohorts differed significantly, as the post-pandemic population was older and had more medical comorbidities than the pre-pandemic cohort. The post-pandemic cohort likely required more urgent medical care than the pre-pandemic cohort, who were more likely to defer medical care.

There were several limitations to this retrospective study. Among the 67 HCOs included in the TrinetX database at the time of query, there was heterogeneity in the number of HCOs which reported CPT codes, as demonstrated in Table 1, introducing a potential information bias. HCOs were located internationally, and varying regulations among countries may have impacted surgical volumes. Otology procedures could not be practically stratified to differentiate pediatric otolaryngology cases from procedures performed on adults, which may have skewed the data on Otology procedural volumes. Finally, due to the retrospective study design, confounding variables could not be controlled due to a lack of availability of clinically relevant patient information.

CONCLUSION

Overall otolaryngology surgical volumes decreased in the two years since the start of the COVID-19 pandemic. However, rebounding trends have been shown in several of the otolaryngology subspecialties, though none have yet maintained or surpassed pre-pandemic baselines. Interestingly, pediatric and otologic sub-specialties seem to have suffered the most significant decrease in case volumes in this dataset.

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